Project TRILLION*: Steering and radiation effects in oriented crystals and their applications implementation into Geant4

*MSCA Global Fellowships, GA 101032975

The 2nd ECFA-INFN Early Career Researcher Meeting
Frascati, Italy, September 30 - October 1, 2024

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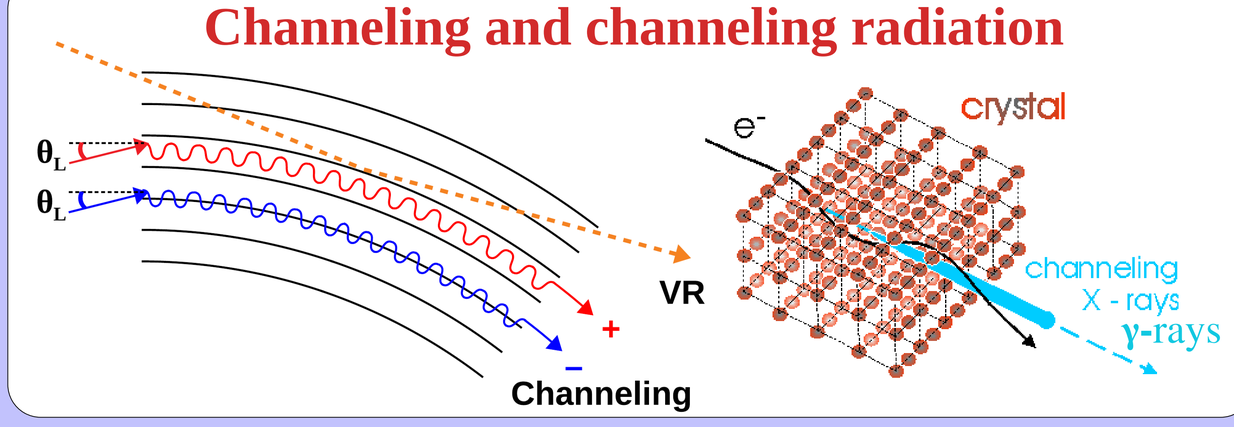
Introduction to TRILLION

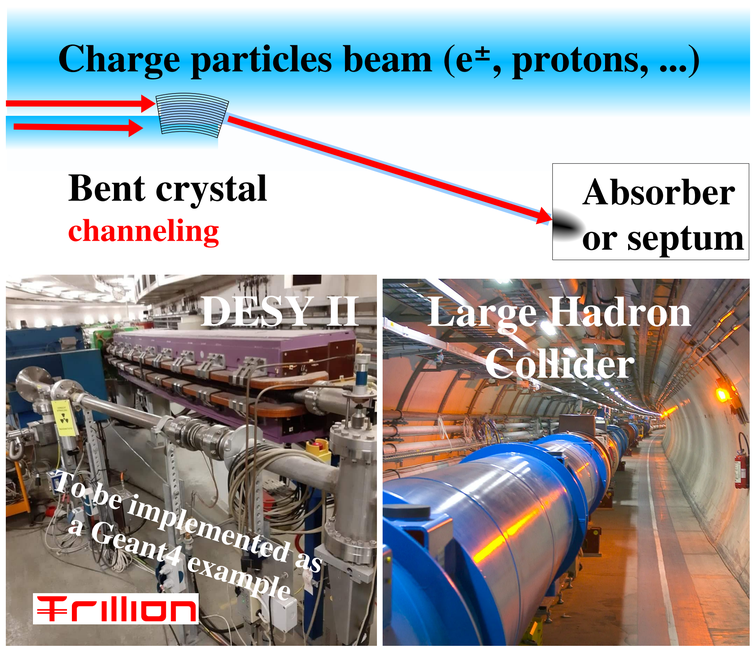
The **Marie Skłodowska-Curie Actions Global Fellowships** project **TRILLION** is dedicated to the implementation of both physics of **electromagnetic processes in oriented crystals** and the design of specific applications of crystalline effects into **Geant4 simulation toolkit**[1] as **Extended Examples** to bring them to a large scientific and industrial community and under a free Geant4 license. **Geant4** is a toolkit for the simulation of the passage of particles through matter.

Channeling and channeling radiation



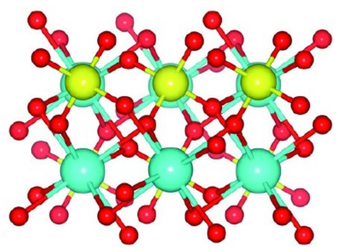
Applications of a crystal[2]

Crystal-based collimation and extraction[3] of charged particles from an accelerator

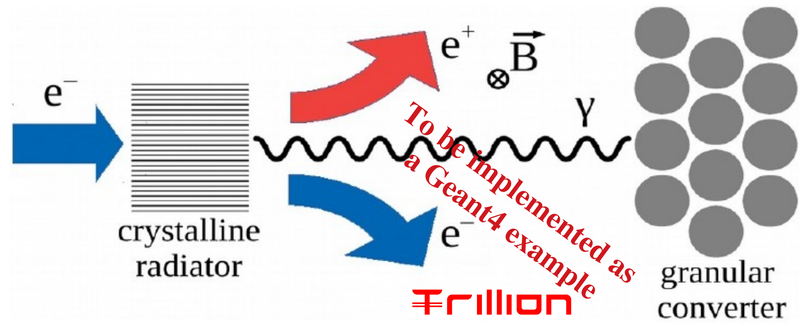


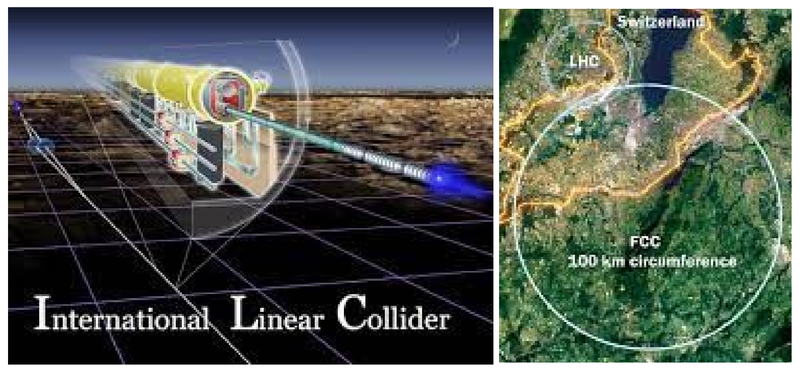
Gamma-ray Space Telescope[4]

Compact EM calorimeter to detect γ-rays

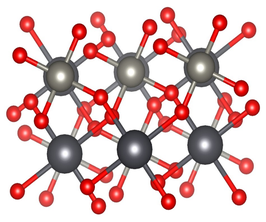


Crystal-based hybrid positron source for future e⁺e⁻ and muon colliders[5]

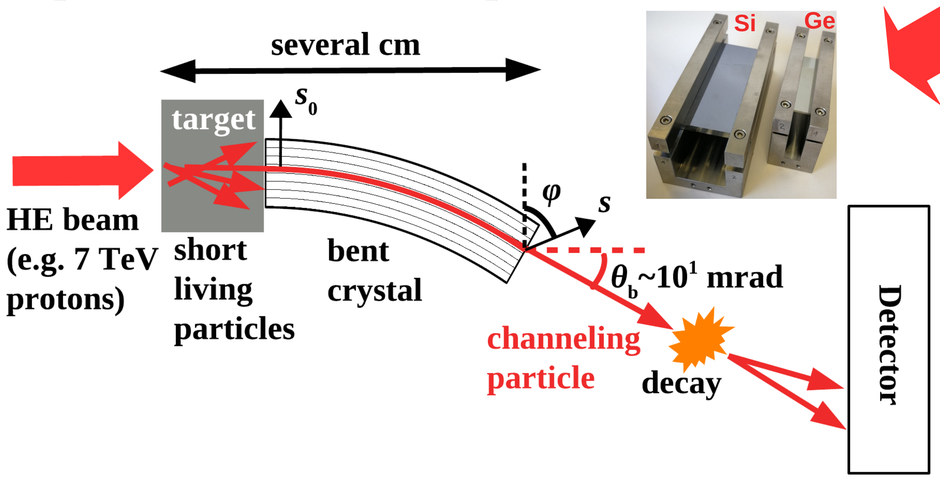




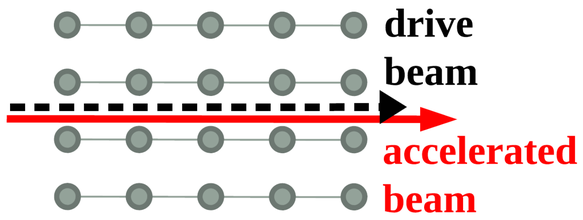
Crystal



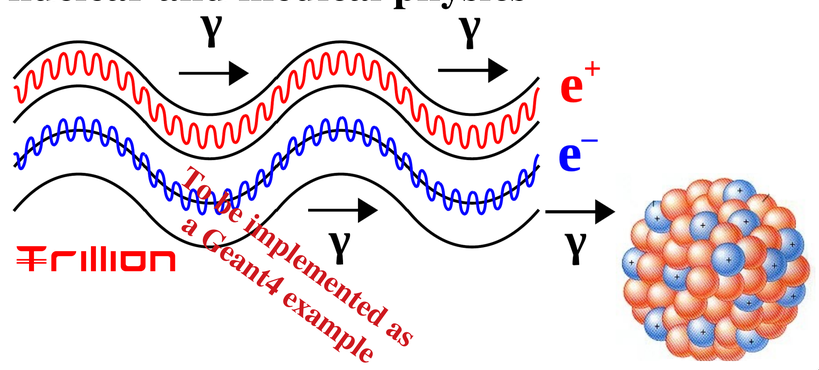
Measurement of magnetic and electric dipole moments of exotic particles[7]



Wakefield acceleration[8]



Crystalline source of intense coherent hard X-ray and gamma radiation, for nuclear and medical physics[6]



Implementation of channeling model into Geant4

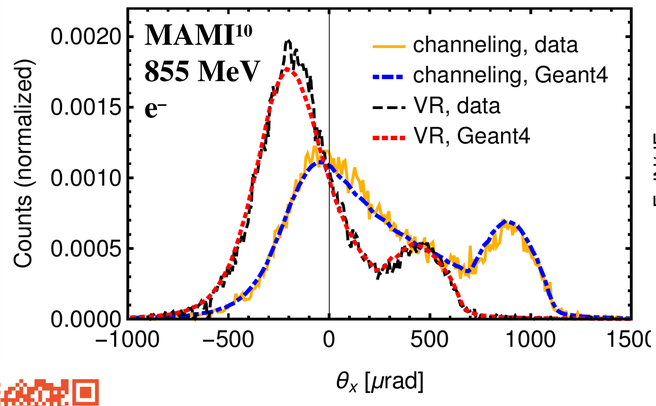
- **CRYSTALRAD** simulation code[9] is a **baseline code** for channeling and channeling radiation model implementation into Geant4.
- The implementation mechanism is **Geant4 FastSim interface**, which is a **PhysicsList independent** model and is activated only in a certain **G4Region**, at a certain **condition** (*ModelTrigger*) and for certain **particles** (*IsApplicable*).

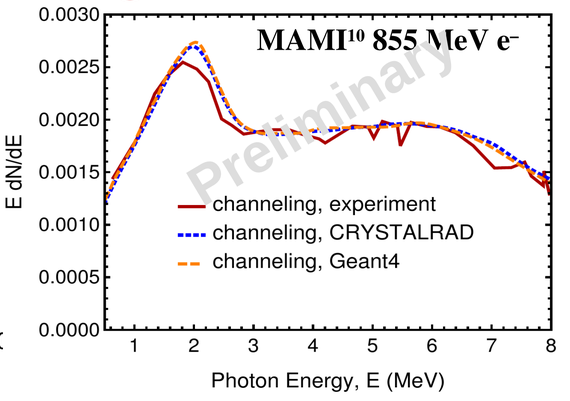
```
G4bool G4ChannelingFastSimModel::IsApplicable(const G4ParticleDefinition& particleType)
G4bool G4ChannelingFastSimModel::ModelTrigger(const G4FastTrack& fastTrack)
void G4ChannelingFastSimModel::DoIt(const G4FastTrack& fastTrack, G4FastStep& fastStep)
```

***G4ChannelingFastSimModel* and *G4BaierKatkov* are in Geant4 kernel since Geant4-11.2.0 (08/12/2023)**

Model description:

Validation of Geant4 channeling model with data[2]





Will be available in Geant4 extended examples ch1 and ch2 at the end of 2024

Conclusions

- Channeling model has been implemented into Geant4 using FastSim interface and validated with experimental data and CRYSTALRAD simulations.
- TRILLION Geant4 examples can be applied in nuclear and medical physics (X- and γ-ray source), for e-e+ synchrotrons and colliders (positron source; beam extraction).

Acknowlegments: A. Sytov acknowledges support by the European Commission (TRILLION project, GA. 101032975), Geant4INFN, EIC-PATHFINDER-OPEN TECHNO-CLS (GA. 101046458). This work is also supported by the KISTI with supercomputing resources including technical support (KSC-2022-CHA-0003).

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5. L. Bandiera et al. Eur. Phys. J. C 82, 699 (2022).
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